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NOTES ON AMERICAN EARTHWORMS OF THE FAMILY LUMBRICIDAE. I-II.

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Information as to variation of taxonomically important characters in our little known endemic lumbricids hitherto has been lacking. Some now can be recorded through the kindness of Dr. G. E. Pickford, Prof. Walter Harman, Ottys Sanders, and others. The author's thanks are extended to all those who have supplied or loaned material.

I

Eisenia lönnbergi (Michaelsen) 1894

Mt. Carmel, New Haven, Conn. In wet soil at bank of river, Oct. 28, 1928, 1-0-3. Dr. G. E. Pickford.

Cockaponsett, Conn. Near Indian caves, Nov. 9, 1941, 0-0-1. Dr. G. E. Pickford.

Cockaponsett State Forest, Conn. In wet soil (pH *ca.* 5.5) under water-logged logs at edge of lake (water level low leaving muddy shore with stumps), Oct. 6, 1940, 0-1-2. Dr. G. E. Pickford. (Clitellate specimens were copulating when taken.)

Meshomasic State Forest, Conn. By stream (pH *ca.* 5.0), April 28, 1935, 0-0-3. In soil (pH *ca.* 5.0) in bank of stream below Hypochilus colony, Nov. 4, 1935, 0-0-1. Dr. G. E. Pickford.

Woodbridge, Conn. In marshy soil of alder copse near Baldwin's Road, Wehawaug River valley, Oct. 21, 1928, 1-0-2. Same locality, in marshy soil (pH *ca.* 6.2), Oct. 16, 1928, 1-0-1. At edge of small pond, June 14, 1931, 0-0-1. Dr. G. E. Pickford.

Tallulah Falls, Georgia. In ravine, in sandy loam in seep of stream, July 27, 1931, 1-0-13. J. M. Valentine per Dr. G. E. Pickford. ("Abundant" according to collector.)

Mt. Vernon, Virginia. From nearby swamp, April 22, 1917, 0-0-1 (macerated). Walter D. Webb Jr., per Prof. E. Carpenter. (Two other Virginia specimens, kindly loaned by Prof. Harman, have been examined.)

External characteristics. Length, 77-104 mm. (Conn.), -130 mm. (Georgia). Diameter in clitellar region which is flat on ventral side, 6-8 mm. Body becomes transversely rectangular in cross section posteriorly. Segments, 114-134 (*cf.* Table). Pigmentation in dorsum, dark, rather nondescript, at least in present condition, possibly lighter in viii-xi near mD. Prostomium epilobous; tongue short, open or closed (3 specimens). Setae begin on ii (33) on which all are usually present, located at four corners of the body posteriorly where $AB <$ or ca. $= CD$, $BC < AA$, AA ca. $= DD$. Nephropores recognizable only on a few of the segments, first seen on iv, usually in or close to *CD* on iv-xiii, between levels of female and male pores on xiv-xvi, elsewhere in median part of *BC* or dorsal to *D* but without regular alternation or segmental symmetry, occasionally in *DD* on one side even in xiv-xvi. First dorsal pore on 4/5 (32), 6/7 (1).

Spermathecal pores on 8/9-10/11 (30 specimens), 8/9-11/12 (1), just lateral to mD, each on a small tumescence and in a longitudinal groove so that four small tubercles seem to be present on each intersegmental furrow. Female pores at eq/xiv just lateral to *B*. Male pores each at bottom of a slight transverse depression, at eq/xv and much nearer *B* than *C*.

Clitellum red (formalin preservation), saddle-shaped, reaching ventrally nearly to *B* or to tubercula pubertatis, 23/24-eq/xxx (1), xxiii-xxx (5), xxiv-xxx (22). Tubercula pubertatis longitudinally placed, rather broad bands just lateral to *B*, on xxvi-xxviii (31), occasionally continued onto anterior half of xxix and/or posterior half of xxv but there gradually narrowed, markedly protuberant (several) and then sometimes with *b* setae on median face, the *b* setae on several other specimens slightly displaced mesially. Epidermis in *AA* of clitellar segments about as thick as in genital tumescences.

Genital tumescences present (or recognizable?) only on three worms, around *c-d* of viii (1), of xi-xii (1), around *a-b* of x (1), of xx-xxx (1, ex copula), of xxiii-xxx (1, ex copula), of xxiii (1). The *a* and *b* setae of xx-xxx (1), xxi-xxx (1), xxii-xxx (8), xxiii-xxix (10), xxiii-xxx (11), xxiv-xxix (1), xxiv-xxx (5), xxvi-xxviii (1) are deeply retracted into the parietes and the margin of each follicle aperture is protuberant as a slight but obvious annular tumescence. The *a* and *b* setae of x (3) and/or the *c* and *d* setae of x (7) likewise are retracted and follicle apertures have an annular tumescence. Male pore tumescences slight, median to the pore, usually not reaching either intersegmental furrow, occasionally quite unrecognizable.

Internal anatomy. Septa 12/13-14/15 muscular and increasingly thickened posteriorly.

Oesophageal wall slightly thickened posteriorly in x but without any trace of sacs. Calciferous glands large, in xi-xii, not quite reaching insertion of 12/13. Intestinal origin in xv (33). Gizzard in xvii-xviii, some special muscularity in xix in at least one of the worms. The typhlosole begins abruptly in region of xxiv-xxvii or may be recognizable from *ca.* xx as a flat horizontal band gradually thickened and heightened posteriorly. The shape in cross section behind xxviii is for a time like that of an inverted T but the ventral margin gradually becomes more rounded. The typhlosole is high, nearly reaching floor of gut and when the ventral portion is cut off readily separates into two lamellae, the space between with only a few delicate fibres and a little granular matter. The end, rather abrupt, normally is in region of c-cxv (*cf.* Table I).

The subneural trunk, adherent to nerve cord, usually is fairly large and filled with blood but when empty may be unrecognizable. A large vessel passes up from each extra-oesophageal trunk in vicinity of 9/10. Last hearts in xi (33), usually small and empty. Hearts of x often smaller than those of ix. Hearts of vi or vi-vii sometimes also are small. Nephridia have been found only from iii posteriorly (lacking in ii?). Nephridial ducts apparently pass into parietes in region of *B*.

Seminal vesicles three pairs, in ix, xi-xii, those of xii the largest, those of ix the smallest though still of fair size. Male deferent ducts appear to be slightly thickened in the entalmost portion and rather sinuous but without definite loops on posterior faces of septa just behind the funnels. Spermathecal ducts slender, usually longer than the ampullae which are in ix-xi or ix-xii. Ovisacs small, slightly lobed in each adult.

Glandular tissue is present on the parietes median to *A* (and also lateral to *B*) in a band that extends from xxx to or well towards xxii and mesially nearly to the nerve cord. Similar tissue is present on the parietes laterally in xi-xii of one worm but none is present over the male pore tumescences in any of these specimens.

Follicles of the retracted genital setae are markedly protuberant into the coelom, thick and opaque, only the ental end of a shaft visible at inner end of a follicle. Such follicles (*c* and *d*) were found in x of several specimens on which annular tumescences of the apertures had not been noticed prior to dissection.

Juveniles. Glandular tissues on the parietes were unrecognizable but the *a* and *b* follicles of xx-xxx were conspicuously protuberant into the coelom, especially in the middle of the series.

Abnormality. Male funnels of x though plicate and iridescent in one sexual worm are only about half the size of those in xi.

Each spermatheca of ix of one worm has two ampullae both of which contain sperm.

The ampullae of the spermathecae in xii of the octothecal worm are smaller than those in the other segments and are transparent though other spermathecae are distended and with spermatozoal iridescence.

Brown bodies. Ovoidal, spheroidal and discoidal bodies of various sizes, in a posterior amputee, fill coelomic cavities of several segments just in front of the anus. These bodies sometimes contain setae and apparently differ from the usual ''brown'' bodies only in being white.

Habitats. E. lönnbergi, in Connecticut, according to Dr. Pickford (*in lit.*) inhabits wet places, commonly along with *Eiseniella tetraedra* (Savigny) 1826 and ''is not found in cultivated soils, fields, forest soils, nor in stagnant boggy ground but rather in banks of streams and rivers or in marshy backwaters.'' Presence in soil with a pH of 4.5 also was mentioned by Dr. Pickford.

Life history. Reproduction presumably is biparental ordinarily as evidence of sperm maturation and/or reception was recognized in all but one of the adults. The exceptional worm (April 28) obviously had not yet copulated nor matured sperm though the clitellum was fairly well developed (presexual clitellate). Marked iridescence in distended spermathecal ampullae and on male funnels, like the large soft seminal vesicles, in the other two April and the June worms, just as clearly indicated sexual maturity and copulation. Iridescence on male funnels and in spermathecae of July specimens (Georgia) was much less marked. Spermathecal ampullae of two of those worms were filled with a watery fluid or pink jelly in which there was no iridescence, and ovisacs were occupied by a brown granular debris. The slight iridescence on male funnels and in spermathecae of some of the fall worms (Oct. 10, 21, 28) and especially the brown debris filling the seminal vesicles again indicated a postsexual state. Two *ex copula* individuals (Oct. 6) and another (Nov. 4) that had recently copulated show that reproduction may occur in the fall also. Slight iridescence on the male funnels showed that some sperm already had been matured in the aclitellate (Oct. 6) worm which had not yet copulated. Whether a summer period of sexual inactivity separates spring and fall breeding seasons remains to be determined.

Parasites. Nematodes were present in the coelomic cavities of x-xi of one worm.

Fairly large cysts, presumably of gregarines, are present in seminal vesicles of several worms where they are quite obvious as soon as the specimen is opened. Other cysts are present in the parietes of several specimens, some even recognizable from the exterior with which they seem to be in communication by a minute aperture. Large, transparent cysts in coelomic cavities of last few segments (several worms) have two hemispheroidal opaque bodies each with a single nucleus. Smaller opaque cysts are numerous in the same region.

Ovoidal bodies with an opaque center and a transparent periphery are attached each by a slender and relatively very long stalk to the parietes of segments behind xix (one worm).

Remarks. The coloration in vivo, according to Dr. Pickford (*in lit.*) is a peculiar, dark grey, irregularly interrupted by lighter areas and so characteristic as to enable easy recognition of the species in the field. Pigment may have been lysed at maturity in the dorsum of viii-xii in one worm, just as happens in *Eisenia foetida* (Savigny) 1826, and may have been leached in others by the formalin. The coloration in some of the Georgia specimens was about the same in the ventrum as in the dorsum and was not externally distinguishable from the darkening of unpigmented worms that takes place, in certain conditions, in formalin.

The clitellum of one *ex copula* worm is markedly tumescent, perhaps more so than on any other specimen. The tumescence of the clitellar region of the copulatory partner is however only very slight.

Whether glandular tissue on parietes lateral to *B* in clitellar region is associated with GS follicles and tumescences or with tubercula pubertatis is unknown.

An anal segment had been reconstituted after amputation (or autotomy) in 16 specimens. Regeneration of a tail in this species, as in *Lumbricus terrestris* L., may not take place.

In the evolution of *E. lönnbergi* a pair of spermathecae opening on 7/8 has been lost. Two pairs opening on 9/10-10/11 have been acquired. The genetic factors responsible for addition of a pair of spermathecae in xii of the octothecal mutant presumably have been involved in the evolution of various lumbricid species.

II

EISENIA CAROLINENSIS Michaelsen 1910

Helodrilus (*Eisenia*) *carolinensis* Michaelsen 1910, Ann. Mus. Zool. St. Petersburg, 15, p. 15. (Type locality, presumably Fayetteville, North Carolina. Type, in Hamburg Mus., intercepted in a plant shipment at Hamburg.)

Eisenia pearsei Stephenson 1933, Proc. Zool. Soc. London, 1932, p. 935, fig. 28. (Type locality, Durham, North Carolina. Types, 13, in Brit. Mus.)

Eisenia carolinensis, Cernosvitov, 1942, Proc. Zool. Soc. London, 111, (B), p. 222. (14 specimens, 5 immature, from Durham, N. C., in Brit. Mus.)

Chapel Hill, North Carolina, April 19, 1932, 0-0-1. J. M. Valentine per Dr. G. E. Pickford.

Highlands, North Carolina. In peaty leaf mould (pH 4.5) among tree roots under leaves near path on way to Primeval Forest, July 26, 1931, 0-0-1. In pocket of sandy black soil (pH 5.0) under dead leaves by stream in woods on path to Primeval Forest, July 25, 1931, 0-0-2. In leaf mould and sandy loam (pH *ca.* 5.0) near path leading up to Whiteside Mountain at altitude of *ca.* 4500 ft., August 21, 1932, 0-0-1. Dr. G. E. Pickford.

Linville, North Carolina. In earth and leaf mould (pH between 5.0 and 6.0) by stream in ravine, near road at 4000 ft. and 14 miles from Blowing Rock, July 31, 1931, 1-0-3. Dr. G. E. Pickford.

Indian Gap (now Newfound Gap, in Great Smoky Mountains), Tennessee. In leaf mould and loamy soil (pH between 5.0 and 6.0) among tree roots and rotting wood, at *ca.* 5000 ft., July 30, 1931, 0-0-2. Dr. G. E. Pickford.

Chilhowie, Virginia. In pocket of loamy soil among grass roots at bank of stream by bridge at *ca.* 3500 ft., about $10\frac{1}{2}$ miles on road to Whitetop Mountain, July 21, 1931, 0-1-4. Dr. G. E. Pickford.

(Several other Virginia worms, loaned by Prof. Harman, also have been examined.)

Tickfaw River Valley, Louisiana, 0-7-0-0. (Mus. Comp. Zool. No. 2061.)

External characteristics. Length, 80-99 mm. (normal worms only). Diameter, 5-7 mm. Segments (122?) 135-142 (*cf.* Table). Pigment unrecognizable in alcoholic and most formalin material. A light red characterizes dorsum of region in front of xv in freshly preserved material (Harman's), and at parietal incisions circular muscle layer looks red. Body four-sided posteriorly, the dorsal surface slightly wider than the ventral, the sides slightly concave. Prostomium epilobous (28 specimens), tongue open and usually quite short. Setae begin on ii (28) on which all usually are present, one pair at each angle of the body posteriorly where $CD <$ or ca. $= AB$, $BC < AA < DD < \frac{1}{2}C$. Nephropores first recognizable on iii, usually close to or dorsal to D on iii-vii, viii or ix, slightly lateral to B on xv-xvi (16) and thence posteriorly often at that level but occasionally in

DD, the location often not the same on opposite sides of the same segment. First dorsal pore on ?5/6 (2), 5/6 (25).

Spermathecal pores on 9/10-10/11 (27), close to mD, each in a quite small tumescence. Female pores equatorial, just lateral to *B,* on xiv. Male pores equatorial, on xv, each in a transverse slit-like depression in median portion of *BC.*

Clitellum red (formalin preservation) or white (one alcoholic), saddle-shaped, reaching ventrally nearly to *B,* on (xxiii)xxiv-xxxi (3), (xxiii)xxiv-xxxi(xxxii) (1), xxiii-xxxi (3), xxiii-xxxii /2 (1), xxiii-xxxii (1), xxiv-xxxi (6), xxiv-xxxii/2 (1), xxiv/2-xxxii/2 (2), xxv-xxxi (1). Epidermis in *AA* of clitellar segments thickened but not as much as in genital tumescences. Tubercula pubertatis lateral to *B,* band-like but not as wide as in *E. lönnbergi,* on xxvii-xxix (25), perhaps occasionally extending slightly onto xxx and/or xxvi.

Genital tumescences conspicuous and transversely elliptical, always including both *a* and *b* setae, on ix (1), xi (3), xii (3), xvi (2), xvii (21), xviii (5), xx (7), xxi (16), xxii (1), xxiii (1), xxiv (3), xxv-xxx (27), xxxi (14), xxxii (2), xxxiii (1), *c-d* of xxiv (1). Each may have a greyish translucent central area. Posterior tumescences are not delimited laterally from the clitellum. Male pore tumescences restricted to xv (7), extending onto xvi but not onto xiv or only very slightly (5), extending well into xiv and xvi (7).

Internal anatomy. Septa 12/13-14/15 muscular and increasingly thickened posteriorly. Longitudinal muscle band at mD and peritoneum apparently without pigment.

Oesophagus with no sacs in x. Calciferous glands as in *E. lönnbergi* Michaelsen 1894, large, moniliform, in xi-xii, separated by a deep constriction, the posterior gland often not reaching insertion of 12/13. Gizzard in xvii-xviii, muscularity occasionally extending slightly beyond insertion of 16/17 or 18/19. Intestinal origin in xv (18). Typhlosole begins in region of xxii-xxvi, abruptly or rather gradually as a flat band that shortly becomes vertical, reaching a height of 1½-2 mm. and to or nearly to floor of gut, thickly lamelliform, the interior with only a few delicate fibres and some granular debris. The highest anterior portion, as in *lönnbergi,* may have a deep groove on the ventral face. The end normally is in region of xcvii-cv (*cf.* Table II).

Subneural trunk quite small, adherent to nerve cord, sometimes quite unrecognizable. Last hearts in xi (18), the hearts of x-xi usually slenderer than the ones in ix, none found in v. Nephridial ducts pass into parietes in the *b* gap.

Seminal vesicles three pairs, in ix, xi-xii (18, including the juvenile), those of xi sometimes (5) smaller to much smaller than the others. Male deferent ducts apparently slightly thickened in the entalmost portion which is in 2-4 very short loops crowded close together on the posterior face of the septum behind the funnel, recognizable (as in *lönnbergi*) on parietes into xv. Spermathecae with short ducts not confined to parietes, ampullae in ix-x (18, including the juvenile).

Follicles of the genital setae (those in copulatory tumescences) enlarged, obviously protuberant into coelom but not as long (nor as muscular?) as in *lönnbergi*. Glands, atrial and such as are present on the parietes in *lönnbergi* and species of *Bimastos* are lacking.

Abnormality and *Variation*. Spermathecal ducts of the Chapel Hill worm are confined to the parietes and each ampulla is deeply constricted by the septum, the portion anterior to the septum of quite different appearance from that behind. Seminal vesicles of ix are lacking. Genital tumescences are present on xxxi-xxxiii as well as on ix and in addition were developed around *c-d* of xii.

Genital tumescences in front of xv and behind xxx otherwise were only on worms from Linville and Chilhowie.

Regeneration. Many of the worms clearly are posterior amputees (*cf.* Table II) and two others may be. No regeneration, except reconstitution of an anal segment, had taken place although the amputation in some cases probably had not been recent.

Life history. Reproduction presumably is biparental as sperm had been matured and/or received in each adult. Spermatophores (at 25/26 in *BC*, on xxviii at mV) and brilliant iridescence in spermathecal ampullae presumably indicated recent copulation by a July 31 worm (Linville) in which no iridescence was recognizable on male funnels. Funnel iridescence was brilliant on the April (Chapel Hill) and four July 21 (Chilhowie) specimens. Male deferent ducts were iridescent in the April worm which is the only one with maximal clitellar tumescence. The single aclitellate individual (July 21, Chilhowie) with discoloration in dorsum of clitellar segments, slight iridescence only at periphery of male funnels and empty spermathecal ampullae clearly is postsexual. Spermathecal ampullae were empty in two worms (Linville) and iridescence was lacking in opaque matter in ampullae of another as well as in transparent watery content of two, in all of which funnel iridescence was not brilliant though still unrestricted. Ovisacs of one of the worms were filled with a brown granular debris. The peak of reproductive activity in these worms presumably was passed at time of preservation. The breeding season presumably extends from April well into July.

Parasites. Nematodes were present in the coelomic cavities of x-xi of one worm. Large and medium-sized cysts, opaque or translucent, probably of gregarines, were numerous in coelomic cavities of the last ten to fifteen segments in several of the posterior amputees.

Remarks. The red coloration of the clitellum appears to be a formalin induced artifact as it was lacking in the single alcoholic specimen.

Nephropores of one worm were lateral to *B* on the right side of xxxiv-xxxix and in *DD* on the left side of xxxv-xxxix.

The spermathecal battery of the ancestral lumbricid presumably comprised two pairs opening to the exterior on 7/8-8/9. In the evolution of *carolinensis* two pairs, opening on 9/10-10/11 have been acquired, and all four of the original ones have been lost. As this is two more than have been eliminated in the ancestry of *lönnbergi,* in that respect *carolinensis* is more advanced.

Seminal vesicles of primitive lumbricids presumably were in four segments, ix-xii. Those of x frequently have been lost in the family but in *Eisenia* they still have not disappeared in some ''formae'' of a species. Presence of vesicles in x of one (or more?) of the types of *pearsei,* is about all that remains to distinguish it from *carolinensis,* and scarcely warrants specific status, if, indeed, any taxonomic recognition.

E. carolinensis and *E. lönnbergi* are the only lumbricids endemic in America that have retained spermathecae. No evidence was found in available material of either species that would indicate elimination of those organs is under way.

Table I

Typhlosole termination and segment number in *Eisenia lönnbergi*

Typhlosole ends in segment	*Atyphlosolate segments*	*Number of segments*	*Locality*	*Remarks*	
60-61*	1	62	Georgia	Amputee	
61-64*	0	64	Georgia	Amputee	
72	4	76	Virginia	Amputee	
74	4	78	Georgia	Amputee	
74	7	81		Amputee	
78	10	88		Amputee	Juvenile
81	6	87	Georgia	Amputee	
82	7	89		Amputee	
84	3	87		Amputee	
84	8	92		Amputee	
86	13	99		Amputee?	Juvenile
100	3	103		Amputee	
100	16	116			
101	13	114			
103	?	107+		Broken	
104	5	109	Georgia	Amputee	
105	8	113	Georgia	Amputee	
100-106*	10	116		Amputee	
107	5	112	Georgia	Amputee	
108	13	121			Ex copula
?	?	124			Damaged
110	14	124			
110	17	127			
111	17	128			
114	18	132			Ex copula
114	3	117		Amputee	
115	19	134			

* Typhlosole ends very gradually rather than abruptly as in other worms.

Posterior ends had been broken off from worms not included above (not available), except for one juvenile, presumably of this species, which has 100 segments.

Table II

Typhlosole termination and segment number in *Eisenia carolinensis*

Typhlosole ends in segment	*Atyphlosolate segments*	*Number of segments*	*Locality*	*Remarks*
65*	6	71		Amputee
73	23	96		Juvenile. Amputee?
79	21	100		Amputee
80	19	101		Amputee
88	26	114		Amputee
82-89†	11	100	Chapel Hill	Amputee
90	32	122		Amputee
93	7	100		Amputee
97	25	122	Indian Gap	Amputee?
98	44	142	Linville	
100	37	137	Highlands	
103	32	135	Chilhowie	
105	24	129	Chilhowie	Amputee?

* Unusually low in seven preceding segments.

† Ends gradually rather than abruptly as in other worms.

Posterior ends had been broken off from the specimens not listed above at time of collection and anal pieces were unavailable.